Non-CO_2 Greenhouse Gases: Nitrous Oxide

Source/Sectors: Agriculture/Agricultural Soil Management

Technology: Improving nitrogen utilization efficiencies (B.1.1.1)

Description of the Technology:

Several agricultural activities increase mineral nitrogen availability in soils for nitrification and denitrification and ultimately increase the amount of N_2O emissions (USEPA, 2006a). Although most of the N_2O emissions from agricultural activities are from soils, the emission flux of N_2O per unit surface area of soil is small and varies greatly across time and space. The flux rate depends significantly on soil type, climate conditions, and soil management practices (IEA, 2000). Basically, there are two types of strategies and related technological options that are applicable to emission reduction of N_2O from agricultural soils. The first type uses measures that improve efficiencies in nitrogen utilization, and the second type inhibits the formation of nitrous oxide (Kowalenko, 1999). It should be noted that there are overlaps in these two types. For example, the use of the nitrification inhibitor and change in irrigation practices are also measures for improving nitrogen fertilizer efficiencies in the field.

With regards to improving nitrogen utilization efficiencies to reduce N_2O emission from agricultural soil, many technological options and practices have been mentioned in literature. However, many of them were mentioned without detailed discussion and information. In addition, very few studies include cost data for implementing mitigation options (DeAngelo *et al.*, 2006). The economic potential for nitrous oxide emission reduction probably is low, except perhaps for efficient fertilizer use (Blok and de Jager, 1994). Below are a list and a brief description of the technological options and practices found from the literature search:

- Soil testing to optimize nitrogen application rate – More nitrogen is usually applied to soil than is needed because of the concern of production lost by under-fertilizing (Branosky & Greenhalgh, 2007). Soil nitrogen testing can be used to help growers adjust nitrogen application rates to match site-specific conditions and have more efficient use of fertilizers (IEA, 2000; O'Hara *et al.*, 2003). The abatement cost for the soil testing option is approximately $\$5/MT_{CO2\text{-}Eq.}$ (Gale and Freund, 2002).
- Controlled released fertilizers (CRFs) – The CRFs are intended to release nutrients at a rate that corresponds with nutrient demand of growing crops. Typically, there is a physical barrier (e.g., a polymer coating) that decreases the rate of nutrient release into the soil. The coatings can be adjusted to match the release rate to the requirements of specific plants (Dalal *et al.*, 2003; IEA, 2000). However, as the release of nutrients from CRFs depends on several factors (temperature, water, root structure), this may be difficult to achieve in practice (Bates, 2001). The abatement cost for the CRF option is approximately $\$50/MT_{CO2\text{-}Eq.}$ (Gale and Freund, 2002).
- Changes in the timing and/or frequency of fertilizer application – The use of fertilizer will be more efficient when the fertilizer application coincides with the period of rapid plant uptake. Several applications of small amounts (split applications) during the growing season would be a more effective means of supply nitrogen for plan growth and the N_2O emission loss should be smaller (IEA, 2000). However, it may not always be practical (Bates, 2001).
- Matching fertilizer nitrogen type to season and general weather pattern – Nitrate-based fertilizer is less stable in soil than the ammonia-based fertilizer. When leaching potential is

high, ammonia-based fertilizer should be used. An example is to use ammonium-based fertilizer when it is wet and nitrate-based fertilizer when it is dry (McTaggert *et al.*, 1994).

- Crop rotation options – Crop rotation entails the growing of different annual or perennial crops in a given field. It is often used as a strategy for improving soil conditions as well as a component of pest control. Corn-alfalfa rotations might also be an effective means of reducing the use of synthetic fertilizers (IEA, 2000).
- Substitute manure for chemical fertilizer – If commercial fertilizers are replaced with livestock manure, N_2O emission from chemical fertilizers can be reduced without increasing emissions from manure (IEA, 2000; de la Chesnaye *et al.*, 2001). Early application and immediate incorporation of manure into soil would reduce the direct N_2O emissions and ammonia volatilization (Dalal *et al.*, 2003).
- Tailor fertilizer to local conditions – It might be possible to develop fertilizer types that are more suitable to specific local conditions and/or adjust application rates to take into account of soil characteristics, soil moisture content, and ambient and soil temperature (IEA, 2000).
- Cover crops – Winter or fallow cover crops can prevent the build-up of residual soil nitrogen, catching nitrogen that would otherwise be emitted as N_2O or leached (Cole *et al.*, 1997; Kroeze & Mosier, 2000; Bates, 2001).
- Improvement of fertilizer spreading – With better spreader maintenance, more uniform spreading can be achieved to increase efficiency and avoid over-application or under application (Worrell, 1994; DeAngelo *et al.*, 2006). Maintaining a fertilizer zone on the edge of fields to prevent losses into ditches at the side of fields would reduce fertilizer loss. Optimization of fertilizer distribution geometry can also prevent losses into ditches (Worrell, 1994). Fertilizer banding can increase efficiency of nitrogen use, reduce volatilization up to 35%, and increase yield up to 15% (Cole *et al.*, 1997; Kroeze and Mosier, 2000). In the band-mode application of easily soluble fertilizer, which was locally put into depth of 10 cm below vegetation, the N_2O emission rate was greatly reduced in comparison with that in broadcasting application (Tsuruta & Aliyama, 2000). Use of precision farming technologies such as yield mapping, global positioning system, and automatic sensing allows crop performance and output to be measured in different areas of a specific field and has potential in reducing nitrogen application and the N_2O emissions (Bates, 2001). Avoiding nitrogen fertilization on urine spots, through precision fertilization, reduced N_2O emissions (Kasper *et al.*, 2002).
- Simple fertilization reduction – This option is to reduce nitrogen-based fertilizer from one-time baseline application of 10%, 20%, or 30% (USEPA, 2006b). However, using this option will have a risk of under-fertilization (DeAngelo *et al.*, 2006).
- Maintain plant residue on the production site – It will allow the nitrogen contained in the residue to be reused, thus reducing the requirement of synthetic fertilizer. It should directly reduce the N_2O production from fertilizer and eliminate the N_2O emission from burning of the plant residue (IEA, 2000).

Effectiveness: Low

Implementability: Low

Reliability: Low

Maturity: Low

Environmental Benefits: It reduces nitrous oxide emission.

Cost Effectiveness: Low

Industry Acceptance Level: Low

Limitations: May affect the yield of crops.

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